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ABSTRACT

Discussed are the objectives of two introductory college biology courses for majors and how well these objectives were fulfilled. Examples of instructional objectives are given, along with sample test items. A description is given of the item analysis applied to the test items, followed by a discussion of how the test items measured whether or not the course objectives were met. (MH)

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CAN A COLLEGE LEVEL BIOLOGY COURSE FOR MAJORS BE EDUCATIONALLY ACCOUNTABLE?*

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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Have we, as educators, reached a point in our society where "Truth in learning" has become as important as "Truth in lending"? We have seen government agencies mandate controls over banks and even auto-mechanics to become accountable for their services. Now, it seems that these same controls are to be levied on those in the educational systems of this nation as well.

For too many years, educators have had the attitude that some information must be kept hidden from the student--or the "don't tell them or they will know everything" syndrome. Course titles do not always indicate what the course concerns. Often advanced courses are nothing more than mere reruns of a lower level course, which may or may not have the same title.

Students are now beginning to demand their rights by voicing their discontent even to the courts of the land. No longer do they stand idly by and accept that which is sometimes even slovenly given. Students are in fact demanding that education for which they have paid; and are not remiss in charging the institution, department, or even the individual teacher to become accountable for their actions.

This manuscript centers about two introductory, majors courses in biology at Ball State University--Principles of Biology I and II.

*This paper was presented by the first author at the National Science Teachers Association, Central Area Convention on October 25, 1975 at Indianapolis, Indiana.

SE 020 722

Nevertheless, it is our hope that many of these remarks will be equally applicable to, or provide some ideas for, any course which you might wish to make educationally accountable.

What do we mean by accountability? According to a recent article in Science Education by three members of our department at Ball State University--Drs. Nisbet, Mertens and Hendrix--"...the key to accountability is student performance".[1] This statement provides us with an operational definition, one that we can measure.

Ball State University is on the quarter system, and usually there are ten to twelve sections in Biology I and from six to ten sections in Biology II. Each section of both courses normally has a maximum of twenty-four students, thus the total number of students ranges from 400 to 525 per quarter. All sections are taught by regular faculty or by advanced doctoral students, who also teach the accompanying laboratory. The schedule followed by students in these courses is composed of three 50-minute lecture-discussion periods and one two-hour lab period per week.

The first author serves as Coordinator of these two courses. Students are provided at the beginning of the quarter with a calendar of topics, reading assignments and lab assignments for the entire quarter. A weekly staff meeting is held for all teaching faculty in these courses to discuss effective teaching strategies for the topics under discussion, to facilitate the coordination of these topics with the upcoming laboratory, to discuss appropriate and available teaching aids, etc.

The goals of these two courses were defined by the teaching staff in Biology I and II using the expertise of faculty who had been teaching

[1]J. J. Nisbet, Thomas R. Mertens and Jon R. Hendrix, "Enhancing Educational Accountability: A Model for University/Secondary School Cooperation," Science Education, 59(2):181-185 (1975).

beginning biology courses for majors. These goals were based upon an assessment of student needs. Using the identified goals, topics as listed in Table I were developed and assigned to these courses. Performance objectives were then defined and written for each of the topics. Since these two biology courses provide the basis for the remainder of our core sequence, a major aim in writing these objectives was to make certain that the topics would be taught at a concept or principles level. Students are provided with a complete list of these performance objectives either at the beginning of the course or at the beginning of each topic, depending upon the discretion of the instructor.

Performance objectives serve a dual purpose, to provide the teaching staff with a guide to the depth and type of coverage for each topic, and, at the same time provide the student with a sequence of faculty expectations. For example, students are told that the exam will cover objectives #1-16, rather than a specific number of chapters. This helps the student to focus his attention on the important concepts and directs his study patterns as to what behaviors are expected of him.

Staff members have collectively written questions to be used on a pre/posttest based on the objectives developed for each topic. The staff collectively establishes face validity for each test item by matching the item with the behavior required in the performance objective. Test items are constantly being revised, as a result of analyzed data obtained from computer output on test results and item analysis.

Before presenting examples of these objectives with their corresponding test items, it is important to note that the staff truly believes that these objectives represent the behavior to be learned in these courses; therefore, if a student meets a level on the pretest that is ordinarily attained by the average student at the end of the course, he/she is allowed

"credit by examination" and moves on to the next course in the core sequence. The actual score at which we allow "credit by examination" on the pretest is obtained by calculating the mean posttest score for each final grade assigned in the course in previous quarters. We base the score at which the student is allowed "credit by examination" at approximately the posttest score received by students in the high "C" range. Each student receiving a pretest score of this range is then individually counseled to move on, or to stay in, the course depending on such factors as: his confidence in trying the next level course; how important this course is to his stated major; whether or not he/she has had other biology or biology-related courses either in college or high school.

Figures 1 and 2 show examples of sample instructional objectives with their corresponding test item. The pre/posttest consists of fifty (50) test items. The student answers these test items by marking an Alpha Answer Sheet. This answer sheet can then be computer graded both for a total score correct (50 possible) and for a subscore on each major topic. The staff is also furnished with a complete test analysis based on a norm-referenced program supplied by the University Testing Service of Indiana State University. Our test is actually a criterion-referenced test, and we keep this in mind in our interpretation of the computer output; however, much information can be gained from such a norm-referenced analysis.

The Alpha Answer Sheet codes each student in each section by name and by social security number. It also provides a read-out from the computer which lists students alphabetically. Since each student has used this answer sheet, each instructor will receive information as shown in Fig. 3 for each of his/her sections. Only a portion of a section is shown in Fig. 3 and names and social security numbers are fictitious.

Computer data provides combined information from all sections in determining the Answer Distribution Analysis as shown by Fig. 4. Of the total number of students responding to each test item, the number responding #1, #2, #3, etc. is shown. The correct answer is indicated by an asterisk. Perusing this information provides us with a quick check on the difficulty of the item. Item #4 obviously was a much easier item than #3. We infer that the distractors apparently were more plausible in item #3. Analyzing this data provides a means of checking to see if the right answer is being scored. In one case when the wrong answer was inadvertently punched into the computer, it was immediately obvious when only a very small number of students answered the item beside the asterisk--a quick check of the test question confirmed what had happened.

The "Examination Item Analysis", Fig. 5, shows a comparison of the same item on the pre/posttest. Five items were selected at random for comparison, and the same item was compared on the pretest and the posttest. The items are compared as to item difficulty. Difficulty is the percentage of students who answered the item correctly. The difficulty score on the pretest indicates how many students have mastered a certain behavior. If all items on a given topic rank high in the "Difficulty" area on the pretest, coverage of this topic might be lessened or simply reviewed briefly during the course. A comparison of the pretest and posttest "Difficulty" will indicate how much population gain has been made on a particular item during the course. This same comparison also tells us how well we are meeting, or not meeting, our students needs by our teaching methods. If it is clear that the gain has not been significant, the staff may ask certain questions of itself, such as: Should teaching methods be altered; is the test item inappropriate; is the level of difficulty too high?

Discrimination is the extent to which an item is answered correctly by the higher scoring students and answered incorrectly by the lower scoring students. This is a quick cross-check of the validity of each test item, and at the same time it provides data concerning the readability of the item.

The computer output also provides "Summary Statistics", Fig. 6. Examining such information provides a quick comparison between sections. Pre/posttest results are shown for four randomly selected sections. The mean scores indicate how well each section was doing at the beginning of the course, and how well each section was doing in comparison with all other sections. The posttest mean indicates the same data at the conclusion of the course. One additional piece of data is provided on the "Summary Statistics". It is a simple, one-factor analysis of variance, addressed to the question of whether all sections may be regarded as having equally high achievement. The F-value in Fig. 6 indicates that there is no significant difference (.01 level) between the sections. The F-value may be used to check on uniformity of student gain among sections. If the F-value is not significant, this indicates that one section has either performed exceptionally well or exceptionally poor as compared to the other sections. The staff can then ask themselves--why? By seeking the answer to this question, we can improve instruction.

The authors wish to introduce a question for thought at this point. If the various sections of the course are coordinated--receiving as nearly as possible the same instruction, why does the variance increase? Shouldn't we be bringing a very heterogenous student population closer together if instruction has been uniform and guided by a specific set of objectives? The sections compared in Fig. 5 indicate that variance has increased. There are several possibilities for explaining this result, such as:

1) Instruction may be helpful to some students, but not to other students; 2) We may be reaching one type of student more effectively than another type of student; 3) A few students do not faithfully attend class, yet do take the posttest. Obviously, we need additional data before we can speculate as to the actual reason.

Figure 7 provides some pertinent norm-referenced information. At first glance and based on a decrease in variance, it appears that we are reaching the upper 27% much more effectively than the remaining 73% if a decrease in variance is an indication of success in teaching. Wrong!-- or at least not necessarily. To be confident that this was actually the case, we would need to be sure that the student populations represented (upper 27%, middle 46%, lower 27%) were the same students on both the pretest and the posttest!

Although our efforts and plans are not fully achieved, we do feel that we have made significant advancement toward making these two introductory courses in biology at Ball State University more accountable.

REFERENCES

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TABLE I

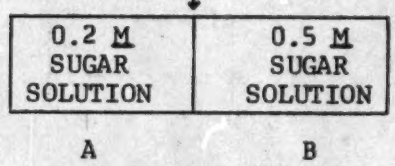
TOPICS COVERED IN
PRINCIPLES OF BIOLOGY I & II

BIOLOGY 111	BIOLOGY 112
DATA INTERPRETATION & BIOSTATISTICS	MEIOSIS AND SEXUAL REPRODUCTION
BIOINSTRUMENTATION & THE TOOLS OF SCIENCE	GENETICS
DIVERSITY OF LIFE	PROTEIN SYNTHESIS & GENES IN ACTION
CELLULAR MACHINERY	PLANT & ANIMAL DEVELOPMENT
MOLECULAR MACHINERY	CELLULAR REGULATION & CONTROL
ENERGY FLOW (THERMO-DYNAMICS & ENZYMES)	EVIDENCES FOR AND MECHANISM OF EVOLUTION
PHOTOSYNTHESIS	PRINCIPLES OF ECOLOGY
CELLULAR RESPIRATION	
DNA AND CHROMOSOMES	
MITOSIS AND ASEXUAL REPRODUCTION	

SAMPLE INSTRUCTIONAL OBJECTIVE:

GIVEN THE CONCENTRATION OF SOLUTIONS SEPARATED BY A DIFFERENTIALLY PERMEABLE MEMBRANE, PREDICT THE FINAL CONDITION OF THE SYSTEM.

CORRESPONDING TEST ITEM:



IN THE EXAMPLE ILLUSTRATED ABOVE, AFTER A PERIOD OF TIME THE LEVEL OF WATER IN THE BEAKER WOULD INDICATE WHICH OF THE FOLLOWING HAD OCCURRED?

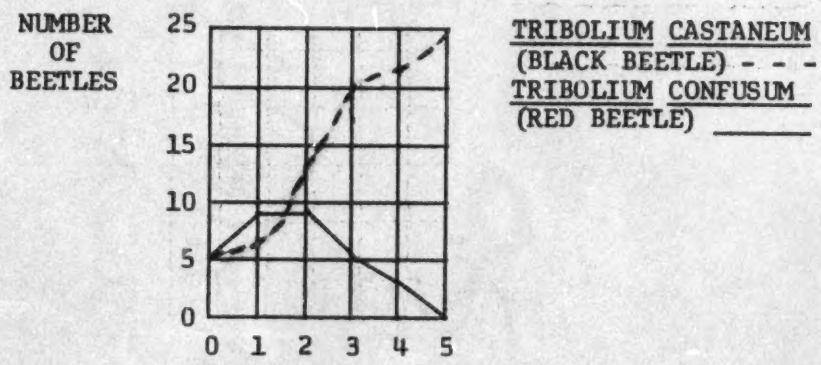
A. EQUAL MOVEMENT IN BOTH DIRECTIONS
B. GREATER NET MOVEMENT FROM A TO B
C. GREATER NET MOVEMENT FROM B TO A
D. NO MOVEMENT
E. NONE OF THE ABOVE

Figure 1

SAMPLE INSTRUCTIONAL OBJECTIVE:

ANALYZE THE RESULTS OF A BIOLOGICAL EXPERIMENT THAT HAS BEEN EXPRESSED GRAPHICALLY.

CORRESPONDING TEST ITEM:



TWO SPECIES (SHOWN ABOVE) OF TRIBOLIUM BEETLES WERE CULTURED IN THE SAME BOTTLE. THE BEST CONCLUSION WHICH CAN BE DRAWN FROM THE ABOVE GRAPH IS THAT:

A. RED AND BLACK BEETLES CAN LIVE TOGETHER AT 34° C AND HIGH HUMIDITY
B. RED BEETLES CANNOT SURVIVE AT 34° C AND HIGH HUMIDITY
C. THE RED BEETLES REPRODUCED FASTER THAN BLACK BEETLES UNDER THESE CONDITIONS
D. BLACK BEETLES ARE STRONGER THAN RED BEETLES
E. BLACK BEETLES COMPETE MORE SUCCESSFULLY THAN RED BEETLES AT 34° C AND HIGH HUMIDITY

Figure 2

BSU EXAM SERVICE BIOLOGY 111 - ALLAMONG SECTION 1

ID	NAME	NUMBER RIGHT	NUMBER WRONG	NUMBER OMITTED	SCORE
311603390	J. Brown	30	20	0	30
303687933	C. James	35	15	0	35
316526453	S. Robinson	21	29	0	21
313503825	J. Stanley	34	16	0	34
310663012	A. Yeager	34	16	0	34

Mean = 29.55 Standard Deviation = 5.43 Number = 22

Figure 3

ANSWER DISTRIBUTION ANALYSIS

ITEM	A/1	B/2	C/3	D/4	E/5	OMITS
1	10	33	13	94*	19	0
2	36	73*	39	9	7	5
3	21	42	14	63*	28	1
4	2	2	112*	47	6	0
5	3	3	140*	10	12	1

* Asterisk indicates correct answer

Figure 4

EXAMINATION ITEM ANALYSIS

	PRETEST		POSTTEST	
ITEM	DIFFICULTY[1]	DISCRIMINATION[2]	DIFFICULTY[1]	DISCRIMINATION[2]
1	43.09	0.40	66.27	0.51
2	30.32	0.20	59.17	0.56
3	31.91	0.22	44.97	0.53
4	18.09	0.30	46.75	0.51
5	54.26	0.44	78.70	0.49

[1] Difficulty is the percentage of students who answered the item correctly.

[2] Discrimination is the extent to which an item is answered correctly by the higher scoring students and answered incorrectly by the lower scoring students.

Figure 5

SUMMARY STATISTICS

	PRETEST			POSTTEST		
SECTION NO.	MEAN	VARIANCE	S.D.	MEAN	VARIANCE	S.D.
1	14.88	18.90	4.35	29.55	29.50	5.43
2	15.88	16.78	4.10	26.18	46.90	6.85
3	16.48	6.86	2.62	27.00	43.75	6.61
4	15.79	37.18	6.10	24.42	48.81	6.99
Total	15.55	20.89	4.57	27.84	43.58	6.60

F-value (based on 9 sections) = 2.68

Figure 6

SUMMARY STATISTICS

	PRETEST			POSTTEST		
	MEAN	VARIANCE	S.D.	MEAN	VARIANCE	S.D.
UPPER 27%	21.10	11.07	3.33	35.84	6.45	2.54
MIDDLE 46%	15.38	2.31	1.52	28.20	6.50	2.55
LOWER 27%	10.32	5.16	2.27	19.20	6.30	2.51

Figure 7